

Claims

What is claimed is:

1. A microturbine engine comprising:

a turbine including a first housing and a first rotor;

5 a generator including a second housing and a generator rotor, the generator rotor supported for low-speed rotation by a low-speed bearing;

a gearbox including a third housing connected to the first housing and the second housing, a pinion gear, and a low-speed gear connected to the generator rotor and at least partially supported by the low-speed bearing;

10 a shaft connected to the first rotor and the pinion gear; and

a first high-speed bearing and a second high-speed bearing positioned to support the first rotor and the shaft for high-speed rotation.

2. The microturbine engine of claim 1, wherein the turbine includes a

15 compressor having a second housing connected to the first housing and a compressor rotor connected to the first rotor.

20 3. The microturbine engine of claim 1, wherein the generator is a synchronous generator.

4. The microturbine engine of claim 1, wherein the first rotor rotates at a speed of at least about 15,000 RPM and the generator rotor rotates at a speed of less than about 4,000 RPM.

5. The microturbine engine of claim 1, wherein the low-speed gear is a ring gear.

6. The microturbine engine of claim 5, wherein the high-speed gear drives a plurality of planetary gears, and each of the planetary gears drives a drive gear, and the drive gears drive the ring gear.

7. The microturbine engine of claim 6, wherein each of the planetary gears is supported for rotation about a planetary axis.

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8. The microturbine engine of claim 6, wherein the planetary gears support the pinion gear for rotation such that the shaft is completely supported by the planetary gears and the pair of high-speed bearings.

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9. The microturbine engine of claim 1, wherein the shaft is a quill shaft.

10. The microturbine engine of claim 9, wherein the quill shaft includes a diaphragm portion that allows for relative movement between the first rotor and the pinion gear.

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11. The microturbine engine of claim 10, wherein the relative movement is limited to angular misalignment and axial displacement.

12. The microturbine engine of claim 1, further comprising a plurality of coupling members coupling the shaft to the first rotor, the coupling members sized to shear when a torque level generated by engine operation exceeds a predetermined value.

5 13. The microturbine engine of claim 12, wherein the first rotor includes a catcher having a first diameter portion and a second diameter portion.

14. The microturbine engine of claim 13, wherein the first diameter portion is sized to receive the shaft during engine operation and the second diameter portion is sized 10 to guide the shaft when the coupling members shear.

15. The microturbine engine of claim 12, wherein the coupling members include a combination of at least one bolt and at least one shear pin.

15 16. The microturbine engine of claim 1, wherein the first rotor includes a turbine shaft, a compressor shaft, and a rotor flange, and wherein a tie-bolt passes through at least a portion of the rotor flange, at least a portion of the turbine shaft, and the entire compressor shaft and engages the turbine shaft and the rotor flange to couple the turbine shaft, the compressor shaft and the rotor flange for high-speed rotation.

17. A microturbine engine comprising:

a turbine including a turbine housing and a turbine rotor;

a compressor including a compressor housing coupled to the turbine housing and

a compressor rotor coupled to the turbine rotor;

5 a rotor flange coupled to the compressor rotor such that the turbine rotor, the compressor rotor, and the rotor flange at least partially define a rotor train;

a first high-speed bearing and a second high-speed bearing coupled to the rotor train and at least partially supporting the rotor train for rotation, the first high-speed bearing and the second high-speed bearing positioned to define a space between the

10 bearings and a space that extends beyond the bearings, at least a portion of the rotor train positioned within the space beyond the bearings to define a cantilever portion having a free end;

a synchronous generator including a generator housing and a generator rotor, the generator rotor supported for low-speed rotation by at least one low-speed bearing;

15 a gearbox including a gearbox housing connected to the compressor housing and the generator housing, the gearbox including a ring gear connected to the generator rotor, a plurality of planetary gears, and a pinion gear positioned to engage each of the planetary gears; and

a quill shaft coupled to the rotor train and the pinion gear such that the quill shaft

20 is fully supported by the second high-speed bearing and the planetary gears.

18. The microturbine engine of claim 17, wherein the turbine rotor rotates at a speed of at least about 15,000 RPM and the generator rotor rotates at a speed of less than about 4,000 RPM.

19. The microturbine engine of claim 17, wherein the pinion gear drives each of the planetary gears, each of the planetary gears drives a drive gear, and the drive gears drive the ring gear.

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20. The microturbine engine of claim 17, wherein each of the planetary gears is supported for rotation about a planetary axis.

21. The microturbine engine of claim 17, wherein the quill shaft includes a 10 diaphragm portion that allows for relative movement between the turbine rotor and the pinion gear.

22. The microturbine engine of claim 21, wherein the relative movement is limited to angular misalignment and axial displacement.

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23. The microturbine engine of claim 17, further comprising a plurality of coupling members positioned to couple the quill shaft to the compressor rotor, the coupling members sized to shear when a torque level generated by engine operation exceeds a predetermined value.

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24. The microturbine engine of claim 23, wherein the coupling members include a combination of at least one bolt and at least one shear pin.

25. The microturbine engine of claim 23, wherein the rotor flange includes a catcher having a first diameter portion and a second diameter portion.

26. The microturbine engine of claim 25, wherein the first diameter portion is 5 sized to receive the quill shaft during engine operation and the second diameter portion is sized to guide the quill shaft when the coupling members shear.

27. The microturbine engine of claim 17, wherein a tie-bolt passes through at least a portion of the rotor flange, at least a portion of the turbine rotor, and the entire 10 compressor rotor and engages the turbine rotor and the rotor flange to couple the turbine rotor, the compressor rotor and the rotor flange for high-speed rotation.

28. The microturbine engine of claim 17, wherein at least a portion of the compressor rotor and the entire turbine rotor are supported in the space beyond the 15 bearings to at least partially define the cantilever portion.

29. The microturbine engine of claim 17, wherein the turbine rotor includes a 20 free end.

30. A method of coupling a rotating element of an engine that operates at a first speed to a driven component that operates at a second speed, the second speed slower than the first speed, the method comprising:

coupling a shaft to the rotating element;

5 supporting the rotating element and the shaft with a first high-speed bearing and a second high-speed bearing such that at least a portion of the rotating element is disposed in a space between the bearings and at least a portion of the rotating element is disposed in a space beyond the bearings;

engaging a second end of the shaft with a plurality of planetary gears;

10 supporting the driven component with at least one low-speed bearing; and

coupling a low-speed gear to the driven component, the low-speed gear coupled to each of the planetary gears.

31. The method of claim 30, wherein the rotating element includes a turbine 15 rotor, a compressor rotor, and a rotor flange.

32. The method of claim 31, further comprising passing a tie-bolt at least partially through the rotor flange and the turbine rotor and completely through the generator rotor.

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33. The method of claim 32, further comprising tightening the tie-bolt to lock the compressor rotor, the turbine rotor and the rotor flange relative to one another.

34. The method of claim 31, wherein the coupling step further comprises attaching a flexible diaphragm to the rotor flange.

5 35. The method of claim 31, further comprising allowing angular misalignment between the shaft and the rotor flange by flexing the diaphragm.

36. The method of claim 34, wherein the attaching step further comprises engaging a plurality of coupling members with the rotor flange and the diaphragm.

10 37. The method of claim 36, wherein the coupling members include at least one bolt and at least one shear pin.

15 38. The method of claim 36, further comprising shearing the coupling members in response to torque level generated by the turbine rotor in excess of a predetermined torque level.

39. The method of claim 38, further comprising providing a catcher formed as part of the rotor flange operable to support the shaft following the shearing of the coupling members.

20 40. The method of claim 30, wherein the driven component is a synchronous generator.

41. The method of claim 30, wherein the first speed is in excess of about 15,000 RPM and the second speed is less than about 4,000 RPM.